BIOECONOMIC ANALYSIS OF HAIRTAIL FISH RESOURCES (TRICHIURUS SP.) IN THE WATERS OF KEBUMEN REGENCY

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DOI https://doi.org/10.18551/rjoas.2018-08.46

BIOECONOMIC ANALYSIS OF HAIRTAIL FISH RESOURCES (TRICHIURUS SP.) IN THE WATERS OF KEBUMEN REGENCY

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ABSTRACT
Hairtail Fish (*Trichiurus sp.*) is one of the potential export commodities in the international market. The worldwide export value of hairtail fish had increased by 128%within the period of 2011-2015. In 2015, it increased by US $15.5 million from the previous year. Great market opportunities to meet market needs lead to increasing fishery resource utilization. Uncontrolled resource exploitation threatens the sustainability of fishery resources. Solutions that can be done to overcome uncontrolled resource exploitation are to lower the effort rate and increase the fishing productivity. Fishing productivity can be improved with the development and innovation of fishing gears and accurate information on hairtail fishing and spawning seasons and zones.

KEY WORDS
Hairtail fish, waters, international market, utilization rate.

The waters of Kebumen Regency are included in the Fishing Management Area (*WPP*) 573. According to Decree of the Ministry of Marine Affairs and Fisheries Number 47 of 2016, some fishery resources in *WPP* 573 are over-exploited, such as reef fish, penaeid shrimp, crab, and squid with utilization rates of 136%, 136%, 105%, and 140% respectively. Meanwhile, the other resources are fully-exploited, such as small pelagic fish, big pelagic fish, demersal fish, lobster, and swimming crab (*Portunus pelagicus*) with utilization rates of 91%, 73%, 96%, 54%, and 64%.

There are 10 dominant demersal fish species caught in *WPP* 573, covering hairtail (23.2%), red snapper (16%), ornate ponyfish (12.8%), seabass/ barramundi (9.9%), pompano (9.8%), threadfin bream (9.3%), croaker (6.3%), black pomfret (4.9%), sea catfish (4.8%), goatfish (3.3%) (Fisheries Research Center, 2014). Of the ten fish species, hairtail fish is the most dominant fish caught by 23.2%.

The international market opportunities for hairtail fish resources are large enough. The value of Indonesian hairtail fish export to the world experienced an increase of 128% during 2011 – 2015. From 2014 to 2015, the hairtail fish export value increased from US $12 million to US $27.5 million. The main destinations of Indonesian hairtail fish export are Vietnam, China, and Korea (the Ministry of Trade, 2016)

Several studies on the utilization of hairtail fish resources in southern Java Island (*WPP 573*) have shown a great opportunity for the improvement of hairtail fish utilization. Dian Putri Utami *et al.* (2012) stated that the fishing effort of hairtail fish in Parigi Waters, Ciamis Regency can still be increased up to 13,312 trips per year.

The magnitude of the international market potential leads to increased fishing efforts. On the other side, increased uncontrolled fishing efforts are feared to threaten the sustainability of hairtail fish resources. This research aimed to analyze the CPUE, MSY, MEY, OAE and utilization rate of hairtail fish resources in the Waters of Kebumen Regency. Actual information on the utilization status of hairtail fish resources in the Waters of Kebumen Regency is expected to be used as inputs in determining sustainable hairtail fishing management strategies in Kebumen Regency

MATERIALS AND METHODS OF RESEARCH

The materials referred to in this research covered all fishing efforts to bring the hairtail fish catch landedin all Fish Auction Place (*TPI*) in Kebumen Regency during 2008-2017. The fishing gears used by fishermen in Kebumen Regency to catch hairtail fish were Drift Gillnet, Fixed Gillnet, Hook and line, and Beach Net. The type of boats used by these fishermen was gross tonnage (GT) with a temple motor driveof 15 horsepower (HP). The location of this research was the waters of Kebumen Regency.

This research was conducted using a descriptivemethod with a case study. Descriptive method is a method of studying the status of a group of men, objects, conditions, systems of thought or a class of thought in the present with the aim to obtain a systematic, factual, and accurate description and relationship between the investigated phenomena (Nazir, 2009).

Data used in this research consisted of primary and secondary data. The primary data were obtained directly from the community or fishermen through a questionnaire method reinforced and supported by observations and interviews. Meanwhile, the secondary data were collected from the literature of related institutions, in this case referring to the Office of Marine Affairs and Fisheries of Kebumen Regency and the Office of Marine Affairs and Fisheries of Central Java Province.

In this research, the data analysis was conducted in the following steps:

Calculating Catch Per Unit Effort (CPUE). According to Nojja *et al* (2014), the value of CPUE is calculated to determine the abundance and utilization rate of fishery resources in certain areas. The hairtail fish CPUE of each fishing gear is calculated using the following formula:

$$\mathrm{CPUE}_t = \frac{Catch_t}{Effort_t}$$

Where: $CPUE_t$: Catch Per Unit Effort in year*t* (kg/ trip); $Catch_t$: Production in year *t* (kg); $Effort_t$: Fishing Effort in year *t* (trip).

Calculating Fishing Power Index (FPI). The highest value of CPUE is the standard CPUE. Each fishing gear has different capabilities in catching hairtail fish, so it needs to be standardized. Standardization of fishing gears will result in the value of Fishing Power Index (FPI). The fishing gear with the highest FPI value can be used as the standard or reference. In general, the fishing gear with the highest CPUE value has FPI value of 1. The FPI value of other fishing gears can be calculated by dividing the CPUE value of the fishing gear with the standard CPUE of the fishing gear. The formula mathematically is presented as follows:

$$CPUEs = \frac{Cs}{Es}$$

$$FPIs = \frac{CPUEs}{CPUEs}$$

$$CPUEi = \frac{Ci}{Ei}$$

$$FPIi = \frac{CPUEi}{CPUEs}$$

Where:

CPUEs: Catch Per Unit Effort of Standard Fishing Gear;
CPUEi: Catch Per Unit Effort of Fishing Gear Type I;
Cs: Total Catch of Standard Fishing Gear;
Ci: Total Catch of Standard Fishing Gear Type I;
Es: Total Effort of Standard Fishing Gear;
Ei: Total Effort of Fishing Gear Type I;

FPIs: Fishing Power Index of Standard Fishing Gear;
FPIi: Fishing Power Index of Fishing Gear Type i.

Calculating MSY, MEY, and OAE. Hairtail fish potential can be predicted by analyzing the catch and fishing effort. According to Spare and Venema (1999), one of the methods that can be used to predict the potential of this resource is Schaefer's production surplus model. The Gordon-Schaefer model-based bioeconomic analysis was developed by Schaefer using the logistic growth function developed by Gordon. There are three conditions of equilibrium in the Gordon-Schaefer model, covering MSY, MEY, and OAE (Dian Wijayanto, 2008). The detailed formula is presented in the following table:

Table 1 – Gordon-Schaefer Equilibrium Formula

	MSY	MEY	OAE
Catch (C)	$a^2/4b$	$aE_{MEY}- b(E_{MEY})^2$	$aE_{OAE}- b(E_{OAE})^2$
Effort (E)	a/2b	(pa-c)/(2pb)	(pa-c)/(pb)
Total Revenue (TR)	C_{MSY}*p	C_{MEY}*p	C_{OAE}*p
Total Cost (TC)	c*E_{MSY}	c*C_{MEY}	c*C_{OAE}
Profit	$TR_{MSY}- TC_{MSY}$	$TR_{MEY}- TC_{MEY}$	$TR_{OAE}- TC_{OAE}$

Source: Wijayanto, 2008.

Utilization Rate. Utilization rate is used to determine the utilization status of resources. The formula of utilization rate is as follows:

$$TP_C = \frac{C_i}{C_{MSY}} \; x \; 100\%$$

Where:
TP_c = Utilization Rate (%);
C_i = Catch in year *i* (kg);
C_{MSY} = Sustainable Maximum Catch (kg).
Meanwhile, the Effort Rate is determined using the formula as follows:

$$TP_E = \frac{E_i}{E_{MSY}} \; x \; 100\%$$

Where:
TP_E = Effort Rate (%);
E_i = Effort in year *i* (kg);
E_{MSY} = Sustainable Maximum Effort (kg).

RESULTS AND DISCUSSION

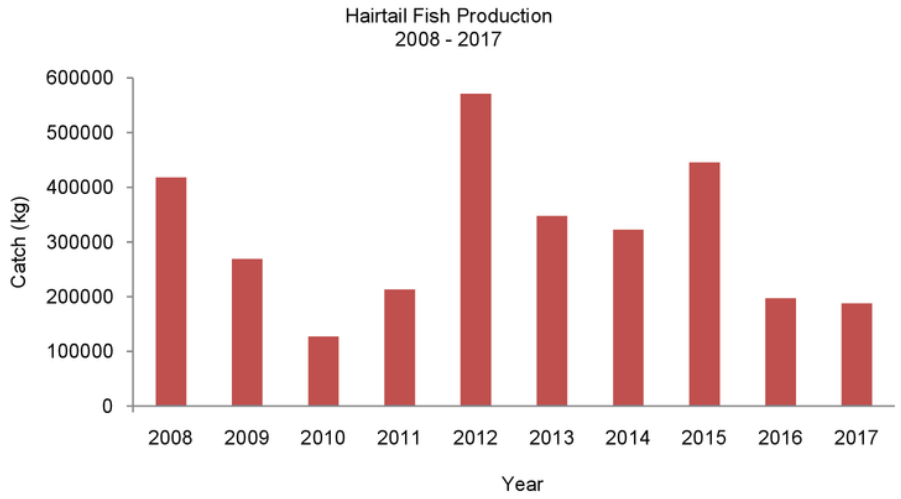
The highest production of hairtail fish was 569.1 tons in 2012 while the lowest production of hairtail fish was 125.7 tons in 2010. As seen in Table 2 below, the hairtail fish production was dominantly caught using Drift Gillnet.

As presented in Table 2, the average production of hairtail fish per year during 2008 – 2017 was 308.04 tons. Of the total average production per year, 266.62 tons of the hairtail fish production was caught using Drift Gilnett. Moreover, the average production of hairtail fish caught using Beach net amounted to 21.65 tons per year while that caught using Fixed Gillnet (Set Net) was 13.16 tons per year. The rest 6.61 tons (per year) were caught using Hook and line. Overall, the production of hairtail fish in Kebumen Regency Waters highly fluctuated. The highest production was 569.1 tons in 2012 and the lowest production amounted to 125.7 tons in 2010.

Table 2 – Production of Hairtail Fish in Kebumen Regency Waters During 2008- 2017

No	Year	Production (ton)				Amount (ton)
		Drift Gillnet	*Fixed Gillnet/ Set Net*	Hook and line	Beach-Net	
1	2008	356.1	60.1			416.2
2	2009	146.9	8.2		112.1	267.2
3	2010	54.5	23.7		47.5	125.7
4	2011	165.5	3.2	4.2	38.2	211.1
5	2012	535.9	10.3	4.2	18.7	569.1
6	2013	305.4	5.4	34.6		345.4
7	2014	298.1	7.3	15.2		320.6
8	2015	425.3	10.6	7.9		443.8
9	2016	193.9	1.4			195.3
10	2017	184.6	1.4			186.0
Total		2,666.2	131.6	66.1	216.5	3,080.4
Average		266.62	13.16	6.61	21.65	308.04

Source: Research (2018).



Source: Research (2018)

Figure 1 – Histogram of Hairtail Fish Production in Kebumen Regency Waters Within the Period of 2008-2017

CPUE (Catch per Unit Effort). CPUE can be used to determine the abundance and utilization rate of a fishery resource (Rahmawati *et al.,* 2013). Based on observations during this research, there were four fishing gears used to catch hairtail fish, namely *Drift Gillnet, Fixed Gillnet (Set Net), Beach Net,* and *Hook and line.* During 2008 – 2017, not all the fishing gears were applied throughout the years. In 2008, 2016, and 2017, the production of hairtail fish came from the application of drift gillnet and fixed gillnet. In 2009 and 2010, three fishing gears were applied to catch hairtail fish, covering drift gillnet, fixed gillnet, and beach net. As for the production of hairtail fish in 2011 and 2012, it was obtained with the use of the four fishing gears. Meanwhile, in 2013, 2014 and 2015, the production of hairtail fish was yielded from the application of drift gillnet, fixed gillnet (set net), and hook and line. The fishing gears that were always used for catching hairtail fish were drift gillnet and fixed gillnet. Table 3 shows that the production, number of trips, CPUE, FPI and Standard Effort of Hairtail Fish Catching in Kebumen Regency during 2008 – 2017.

Table 3 – Production, Trip, CPUE, FPI, and Utilization Effort of Hairtail Fish in Kebumen Regency Waters during 2008-2017

Year	Fishing Gear Type	Number of Trips	Production (kg)	CPUE (kg/Trip)	FPI	Standard Effort (Trip)
2008	Drift Gillnet	36,476	356,124	9.76	1.0000	36,476
	Fixed Gillnet	29,494	60,076	2.04	0.2086	6,153
	Total	65,970	416,200			42,629
2009	Drift Gillnet	2,461	146,900	59.69	1.0000	2,461
	Fixed Gillnet	1,326	8,200	6.18	0.1036	137
	Beach net	2,550	112,100	43.96		1,878
	Total	6,337	267,200			4,476
2010	Drift Gillnet	9,875	54,500	5.52	1.0000	9,875
	Fixed Gillnet	7,642	23,700	3.10	0.5619	4,294
	Beach net	9,957	47,500	4.77	0.8644	8,607
	Total	27,474	125,700			22,776
2011	Drift Gillnet	2,461	165,500	67.25	1.0000	2,461
	Fixed Gillnet	1,326	3,210	2.42	0.0360	48
	Hook and line	1,262	4,200	3.33	0.0495	62
	Beach net	2,550	38,200	14.98	0.2228	568
	Total	7,599	211,110			3,139
2012	Drift Gillnet	9,875	535,900	54.27	1.0000	9,875
	Fixed Gillnet	7,642	10,321	1.35	0.0249	190
	Hook and line	4,222	4,200	0.99	0.0183	77
	Beach net	9,957	18,700	1.88	0.0346	345
	Total	31,696	569,121			10,487
2013	Drift Gillnet	50,863	305,400	6.00	0.5997	30,505
	Fixed Gillnet	3,542	5,400	1.52	0.1523	539
	Hook and line	3,456	34,600	10.01	1.0000	3,456
	Total	57,861	345,400			34,500
2014	Drift Gillnet	46,860	298,100	6.36	0.2557	11,983
	Fixed Gillnet	6,138	7,310	1.19	0.0479	294
	Hook and line	611	15,200	24.88	1.0000	611
	Total	53,609	320,610			12,888
2015	Drift Gillnet	37,240	425,342	11.42	1.0000	37,240
	Fixed Gillnet	4,552	10,564	2.32	0.2032	925
	Hook and line	1,549	7,910	5.11	0.4471	693
	Total	43,341	443,817			38,857
2016	Drift Gillnet	13,745	193,931	14.11	1.0000	13,745
	Fixed Gillnet	2,013	1,421	0.71	0.0500	101
	Total	15,758	195,352			13,846
2017	Drift Gillnet	39,721	184,567	4.65	1.0000	39,721
	Fixed Gillnet	1,005	1,421	1.41	0.3043	306
	Total	40,726	185,988			40,027

Source: Research (2018).

The number of trips from 2008 to 2017 very fluctuated. The smallest number of trips was 6,337 trips in 2009 while the largest number of trips was 65,970 trips in 2008. After standardization, the smallest number of standard trips was 3,139 trips in 2011 and the largest one was 42,629 trips in 2008. The lowest value of standard CPUE reached 4.65 kg/ trip in 2017 and the highest value was 67.25 kg/ trip in 2011.

Various studies have shown a negative correlation between CPUE and Effort. Patria, *et al.* (2014) stated that there is a negative correlation between the CPUE and Effort of shrimp catching in Cilacap Regency. This indicates that the higher effort of shrimp catching will decrease the CPUE value.

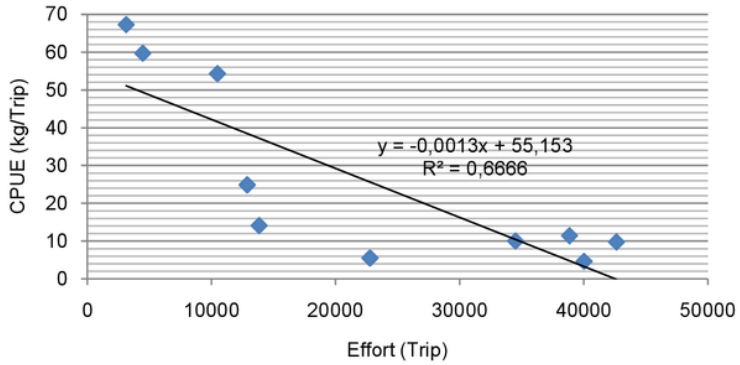
Table 4 – Correlation between Effort and CPUE

Year	Total Production (kg)	Standard Effort (trip)	Standard CPUE (kg/trip)
2008	416.2	42,629	9.76
2009	267.2	4,476	59.69
2010	125.7	22,776	5.52
2011	211.1	3,139	67.25
2012	569.1	10,487	54.27
2013	345.4	34,500	10.01
2014	320.6	12,888	24.88
2015	443.8	38,857	11.42
2016	195.3	13,846	14.11
2017	186.0	40,027	4.65

Source: Research (2018).

Correlation between CPUE and Effort. Figure 2 below shows that the correlation between the CPUE and Effort was negative. It means that every increase in the fishing effort would decrease the catch per unit effort (CPUE). Based on the graph of the correlation between the CPUE and Effort of hairtail fish in Kebumen Regency Waters during 2008 – 2017, the linear equation obtained was $y = 55.15 - 0.001x$ with $R^2 = 0.666$, meaning that the intercept value (a) was 55.15 and the slope value (b) was 0.001. This equation shows that:

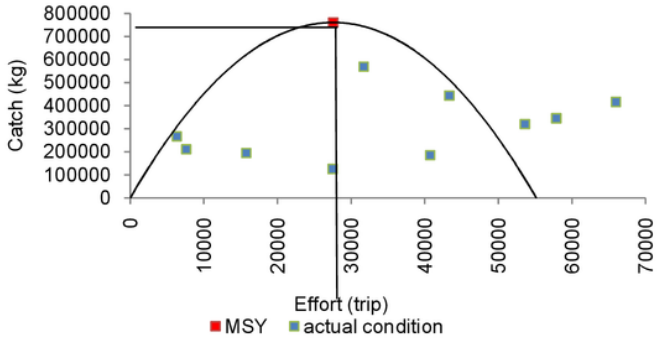
- Any addition of 1 trip of Effort would cause the CPUE value to decrease by 0.001 kg/ trip and any reduction of 1 trip of Effort would increase the CPUE value by 0.001 kg/ trip;
- The determination coefficient (R^2) of 0.666 or 66.6% indicates that the 66.6% of the CPUE value was influenced by the Effort value while the rest 33.4% was influenced by other factors;
- The correlation coefficient (R) of 0.82 indicates a close correlation between the CPUE and Effort.



Source: Research (2018)

Figure 2 – Correlation Between CPUE and Effort of Hairtail Fish Within the Period of 2008-2017

MSY, MEY, and OAE. MSY is a reference for fishery resources management in an area that is still likely to be improved.By knowing MSY, the utilization rate of fishery resources will be maintained so that the resource stock will always be available at a safe level. According to Widodo and Suadi (2006), MSY is the highest or maximum catch that can be yielded year by year by a fishery resource.



Source: Research (2018)

Figure 3 – MSY Curve of Hairtail Fishin Kebumen Regency Waters Within the Period of 2008-2017

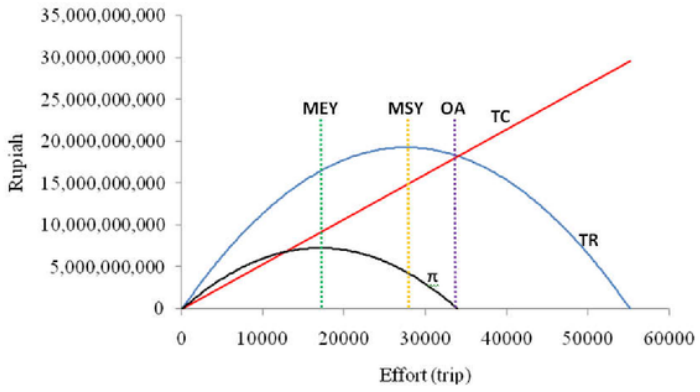
Based on the Schaefer model, the optimum effort (E_{MSY}) of hairtail fish resources in Kebumen Regency Waters was 27,575 trips/ year. Meanwhile, the sustainable or maximum catch (C_{MSY}) was 760,380 kg/ year. Viewed from the resulted sustainable catch value, it can be said that the actual catches of hairtail fish in Kebumen Regency Waters within the period of 2008 – 2017 have not reached the maximum catch (C_{MSY}) but the efforts made have exceeded the maximum effort (E_{MSY}).

Table 5 – Calculation Results of MSY, MEY, andOAE of Hairtail Fish in Kebumen Regency Waters within the Period 2008 – 2017

12	MSY	MEY	OAE
Catch (C)	760.380 kg/year	648.311 kg/year	719.388 kg/year
Effort (E)	27.575 trip/year	16.988 trip/year	33.977 trip/year
Total Revenue (TR)	IDR 19.304.543.308	Rp. 16.459.337.395	Rp. 18.263.845.552
Total Cost (TC)	IDR 14.822.334.600	Rp. 9.131.922.776	Rp. 182.63.845.552
Profit (π)	IDR 4.482.208.708	Rp. 7.327.414.620	Rp. 0

Source: Research Results (2018).

Table 3 shows that the use of Drift Gillnet resulted in the highest average CPUE value. Therefore, this fishing gear was further analyzed for its economic profit. After determining the average economic profit, it was obtained that the price of hairtail fish was IDR 25,388 per kg and the price per trip was IDR 537,528.00. The economic profit under MSY condition was IDR 4,482,208,708.00. Meanwhile, under MEY condition, it was obtained that the maximum catch (C_{MEY}) was 648,311 kg/ year with the effort (E_{MEY}) of 16,988 trips/ year, resulting in the economic profit of IDR 7,327,411,620.00. Furthermore, under OAE condition, the maximum catch (C_{OAE}) was 719,388 kg/ year with the effort (E_{OAE}) of 33,977 trips/ year, The graph of the MSY, MEY, OAE, TR, TC and Profit resultsis presented in Figure 4 below.



Source: Research Results (2018)

Figure 4 – MSY, MEY, OAE, TR, TC andProfit Curves of Hairtail Fish in Kebumen Regency Waters within the Period of 2008 - 2017

Utilization Rate. The utilization rate of hairtail fish for the last 10 years has very fluctuated. The average value of $TP_C$from 2008 to 2017 was 40.51%. The highest TP_Cvalue occurred in 2012 amounted to 74.85% while the lowest TP_Cvalue was 16.53% in 2010. The average value of $TP_E$was 127.06%. The highest TP_E valuewas 239.24% in 2008 while the lowest TP_E value was 22.98% in 2009.

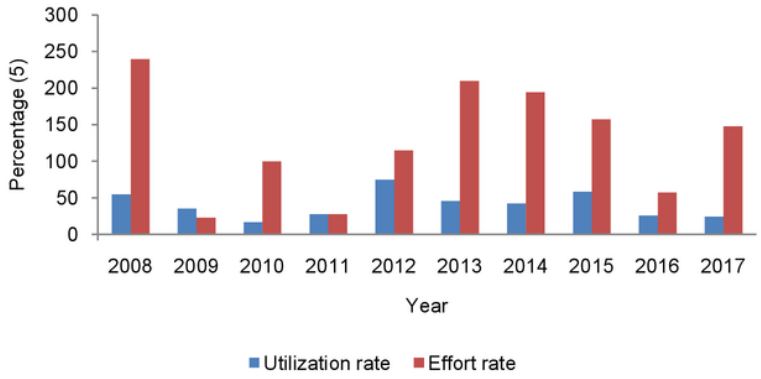
Within the period of 2008 – 2017, the utilization rate (TP_C) was still below 100%. However, the production can still be improved. In contrast, the average effort rate (TP_E) was more than 100%. Until 2011, there had been an attempt to lower the effort rate per year, but the effort went back up to an effort rate of more than 100% in 2012. TP_Evalues that exceed

E_{MSY} can threaten resource sustainability. Reduction of TP_E value and increase in fishing gear effectiveness can be one solution that can be done to increase the production of hairtail fish by still concerning on the resource preservation.

Table 6 – Utilization Rate of Hairtail Fish in Kebumen Regency during 2008-2017

Year	Production (kg)	C_{MSY} (kg)	TP_C (%)	Effort (trip)	E_{MSY} (trip)	TP_E (%)
2008	416,200	760,380	54.74	65,970	27,575	239.24
2009	267,200	760,380	35.14	6,337	27,575	22.98
2010	125,700	760,380	16.53	27,474	27,575	99.63
2011	211,110	760,380	27.76	7,599	27,575	27.56
2012	569,121	760,380	74.85	31,696	27,575	114.94
2013	345,400	760,380	45.42	57,861	27,575	209.83
2014	320,610	760,380	42.16	53,609	27,575	194.41
2015	443,816	760,380	58.37	43,341	27,575	157.17
2016	195,351	760,380	25.69	15,758	27,575	57.15
2017	185,988	760,380	24.46	40,726	27,575	147.69
Rata-rata			40.51			127.06

Source: Research Results (2018).



Source: Research Results (2018)

Figure 5 – Utilization Rate of Hairtail Fish in Kebumen Regency Waters Within the Period of 2008-2017

CONCLUSION AND SUGGESTIONS

The results of this research have led us to conclude that:

- The C_{MSY} value was 760,308 kg/ year and the E_{MSY} value was 25,575 trips/ year with the economic profit of IDR 4,482,208,708.00;
- The C_{MEY} value was 648,311 kg/ year and the E_{MEY} value was 16,988 trips/ year with the economic profit of IDR 7,327,414,620.00;
- The C_{OAE} value was 719,388 kg/ year and the E_{OAE} value was 33,977 trips/ year;
- The average TP_C value was 40.51% per year and the TP_E value was 127.06% per year. Both of these values indicate that the resource utilization is not effective because the effort rate is more than 100% yet the production is still far below 100%.

Taken together, the results of this research would seem to suggest that:

- There should be a limitation for the fishing effort rate per year by limiting the number of trips per year;
- There should be development and innovation of hairtail fishing gears so that the fishing effectiveness can increase;
- There should be precise and accurate information about fishing seasons and zones so as to increase the fishing productivity per year.

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